

Is *Euchloe falloui* Allard, 1867 (Pieridae) the butterfly with the longest diapause?

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Abstract. This paper presents the longest known incidence of pupal diapause in butterflies. *Euchloe falloui* Allard (Pieridae) from the Negev desert in Israel, is reported to remain up to fifteen years in the pupal stage. Other new observations on extended pupal diapause in desert butterflies are communicated for comparison.

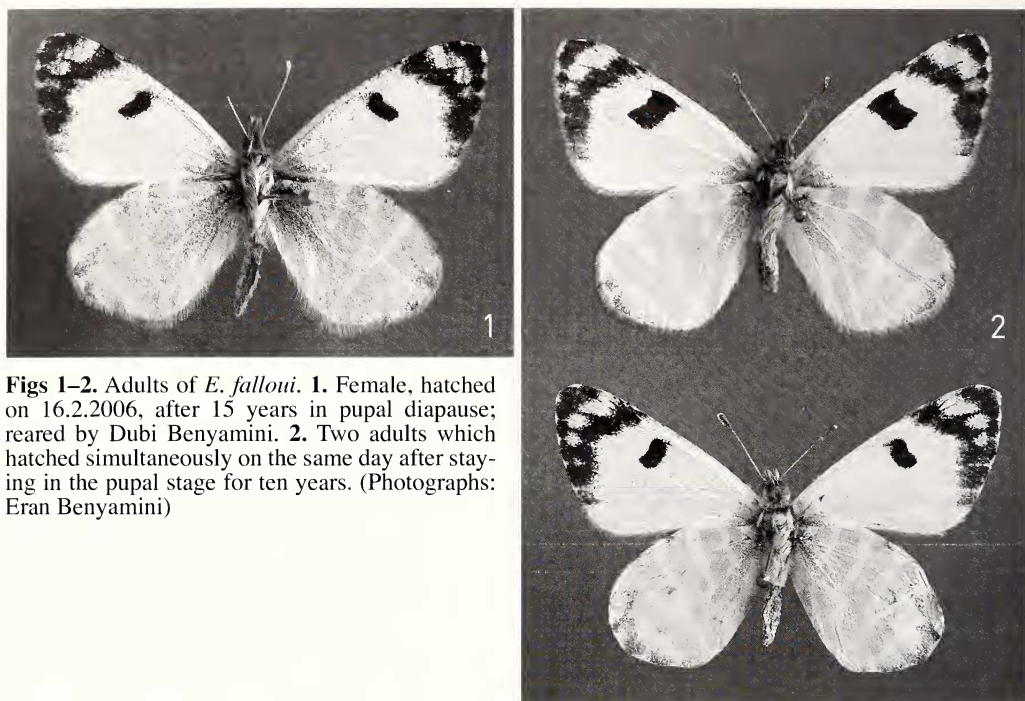
Long term pupal diapause of *Euchloe falloui*

Euchloe falloui Allard, 1867 is a typical spring desert pierid flying in one to three annual broods pending local availability of its Brassicaceae host-plants. It is distributed across the Sahara from Morocco to the Sinai Peninsula, NW Arabian Peninsula, South Israel and South Jordan (Tennent 1996; Larsen 1990; Pittaway 1985; Benyamini 2002).

In spring 1983 I bred a field collected larva from East Sinai. This last instar larva was feeding on a large *Schouwia thebaica* Webb. (a desert annual Brassicaceae plant). In 1991 when this live pupa had still not hatched I decided to move to a larger scale experiment. A caged fertile female from the Negev desert laid tens of eggs on *Moricandia nitens* (Viv.) Dur. et Barr. (a desert perennial Brassicaceae). Subsequently, sixty pupae started the run for this “world championship”. After ten years only seven pupae (11%) survived; two hatched simultaneously on the same day after about 3650 days in diapause, two were deep-frozen for further analysis, two hatched after thirteen years and the last one, a female, which pupated on 01.v.1991, hatched successfully on 16.ii.2006, i.e. nearly fifteen years after entering diapause. No artificial wetting was used to expedite the eclosion. This single specimen survived some 5430 days in the pupal stage relying on its own internal energy sources for survival throughout this extended period. *Euchloe falloui* generally diapause, but the length of long term diapause varies from one to fifteen years.

Other pupal diapause “champions” in arid habitats

In permanent desert butterfly species in Israel, pupal diapause is a common strategy in Papilionidae, Pieridae, and Lycaenidae, because without rain there are no or minimal host-plants available and the long term diapause is a clear survival must. The results of my rearing experienced with Middle East butterflies place the Pieridae in first place: after *Euchloe falloui* (15 years) come *E. crameri aegyptiaca* Verity (9 years), *E. belemia* Esper (7 years), *Elphinstonia charlonia* Donzel and *Zegris eupheme uarda* Hemming (5 years each), *Euchloe ausonia* Hübner (3 years), and *Anthocharis cardamines phoenissa* von Kalchberg (2 years – a single record of Christodoulos Makris from Lemesos, Cyprus). Papilionidae comes next with records of up to five years: *Papilio saharae*



Figs 1–2. Adults of *E. falloui*. **1.** Female, hatched on 16.2.2006, after 15 years in pupal diapause; reared by Dubi Benyamini. **2.** Two adults which hatched simultaneously on the same day after staying in the pupal stage for ten years. (Photographs: Eran Benyamini)

Oberthür (5 years), *P. alexanor* Esper (4 years – Nakamura & Ae (1977) reported three years only), *Archon apollinus* Herbst (2 or even 3 years), and *P. machaon syriacus* Verity (2 years - only in the Negev Mts.). The following Lycaenids are reported here for the first time to have long term pupal diapause: *Pseudophilotes abencerragus nabataeus* Graves (4 years), *Iolana alfierii* Wiltshire (3 years), *Tomares nesimachus* Oberthür (3 years), and *Pseudophilotes jordanicus* Benyamini (one live pupa retained since June 2006 is now entering its third year of diapause).

A similar situation exists in North America where a pierid species has the longest known diapause: *Anthocharis cethura pima* Edwards emerged after nine years (Todd Staut, pers. comm.) while *Papilio zelicaon* Lucas and *Papilio coloro* Wright (*P. polyxenes coloro*) are known to diapause for up to six years (Art Shapiro, pers. comm.; Powell 1987). In Chile I found a two-year diapause in *Battus polydamas archidamas* Boisduval (Papilionidae) which possibly suggests that an as yet unknown local desert pierid there has developed longer pupal diapause. *Hypsochila wagenknechtii sulphurodice* Ureta an Atacama Desert species or *Tatochila mercedis macrodice* Staudinger a Tarapaca (Northern Chile) species are possible candidates. There is no question that many other Asian and African desert species will be found to have similar behaviour.

Discussion

Long term pupal diapause is documented at least since the end of the nineteenth century (Dyar 1891; Riley 1892) but has started to receive scientific attention since the early

1970's. While the Yucca Moth (*Prodoxus inversus*, Prodoxidae) was well documented to have up to 30 years diapause in the pupal stage (Powell 1987, 1989, 2001) thus far no species of butterfly came even close to it. To add to the results mentioned above I plan to publish my findings in detail (Benyamini & Benyamini, unpubl.) in trying to link the expected length of diapause with internal (physiological) and external (climatic) conditions. Preliminary conclusions suggest that two main factors dictate the solution: 1) Planned/ programmed risk sharing function, 2) Opportunistic function. Each one is using internal sensors and accumulated “knowledge” or software as we call it nowadays.

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